

**RESPIRATORY PROTECTION PROGRAM
MEDICAL CLEARANCE FOR RESPIRATOR USE**

*NASA Lewis Research Center
Occupational Medicine Service*

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Background

Occupational exposures to various inhalants cause a large portion of occupational morbidity and mortality. The United States Department of Labor estimates that 65,000 U.S. workers annually develop respiratory disease because of work-related exposures, and 25,000 people die from these diseases every year. Many, if not all, of these cases are entirely preventable.

A complete Respiratory Protection Program, as defined by the Occupational Safety and Health Administration (OSHA) in the CFR 1910.134, includes provision for on-site hazard control measures incorporating occupational procedures; engineering controls; and the selection, fitting, use, and care of various kinds of personal respiratory protective gear. Additionally, health hazards in the workplace need to be identified and evaluated and permissible exposure limits then need to be ascertained. Methods of continued environmental monitoring to ensure that the state's permissible exposure limits (PEL) are not exceeded must be implemented. And always an ongoing priority is the education of the employee and employer about the toxicity of hazards and the safety measures designed to protect the worker from these hazards.

To cover all of the components of a Respiratory Protection Program is beyond the scope of this document and the jurisdiction of the Office of Occupational Medicine Services (OMS). Rather, this document will cover the rationale, procedures, and interpretation of results for the medical clearance of employee for use of personal respiratory protection devices.

The human cardiopulmonary system is a wonderfully complex and yet durable network directly involving not only the lungs, but the heart and blood vessels as well. At the most basic level, this system efficiently oxygenates the blood and removes the waste product, carbon dioxide (CO₂). There are many natural built-in defense

mechanisms such as nose hairs and the cilia-lined mucous membranes of the respiratory tract that effectively filter larger dust particles from the inhaled air. However, in light of cardiopulmonary disease, damage to the respiratory tract from cigarette smoke and other irritants or a high concentration of air contaminants that overwhelm the natural defense mechanisms, dusts, gases, sprays, vapors, fumes, and even radiation can be inhaled directly into the lungs. With repeated exposures to these various toxic inhalants, significant lung damage with measurable clinical effects can be incurred. Often inhalants have an immediate toxic effect which can even prove fatal, but more frequently the physical damage becomes evident years after the initial exposure.

Minimizing the inhalation of harmful dusts, fumes, or vapors is the most effective method of preventing occupational lung diseases. Decreasing the inhalant concentration is accomplished through engineering control measures, with attention to appropriate ventilation and safe work practices. When needed, respiratory personal protective devices (respirators) are used to further minimize inhalant exposures.

There are several varieties of respirators, each with specific criteria for their use. However, all respirators impose added physiologic burdens on an individual. Not all people have the pulmonary and/or cardiovascular reserve available to accommodate this extra physiologic strain. Therefore, medical clearance should be required prior to the issuance of any respirator and periodically repeated if there is continued respirator use.

Among the physiologic loads imposed by respirators, there is an increase in "dead space," representing the volume of exhaled air that is rebreathed from the mask with each inspiration. Rebreathing this dead space air requires either an increased respiratory rate or an increase in the total volume of air breathed per breath in order to overcome the dead space effect. If an individual has significant respiratory disease, one or the other compensatory mechanisms to increase ventilation may not be achievable. Also, there is a resistance to airflow, especially when using a non-powered air-purifying respirator, that is called "flow resistive load." Increased pleural pressure must be generated to overcome the airflow resistance which causes an increase in respiratory work. If a respirator has significant expiratory impedance then, upon expiration, the intrathoracic pressure will need to be higher which will also increase the work of respiration. Increased respiratory work may produce dyspnea (shortness of breath). An

increase in inspiratory effort will lead to a concomitant decrease in expiratory time, which may also cause dyspnea.

The increased intrathoracic pressures required to overcome the airflow resistance will decrease filling of the heart with blood during diastole (relaxation). This may decrease the cardiac output if the individual does not have the cardiac reserve necessary to initiate a compensatory increase in heart rate, as described by the equation of cardiac physiology:

$$\text{Cardiac output} = \text{Stroke volume} \times \text{Heart rate}$$

Also, myocardial ischemia can occur in individuals with significant coronary artery disease when the heart rate increases to maintain adequate cardiac output.

Other added stresses imposed by respirators are related to the physical characteristics of the device itself. The weight of a respirator (SCBA's can weigh up to 30 pounds) will increase energy demands just to carry it, and impose additional strain to the back and contribute to postural instability. Mobility can be limited by wearing a respirator. An individual's field of vision and clarity of vision is impeded. Speaking is difficult while wearing a respirator. Also, there may be a decreased ability to eliminate heat while wearing a respirator.

Certain pulmonary, cardiovascular, psychiatric, or other diseases may interfere with respirator use. Pulmonary diseases are generally classified as "restrictive" lung diseases (pulmonary fibrosis, silicosis, asbestosis, morbid obesity, severe kyphoscoliosis) and "obstructive" lung diseases (asthma, chronic bronchitis, emphysema, bronchiectasis). Restrictive lung diseases are characterized by a decrease in lung compliance, and it therefore may be difficult for these individuals to increase their tidal volume. Obstructive lung diseases are characterized by an increase in physiologic dead space and increased airway resistance. Wearing a respirator in either case would only exacerbate these already existing problems, and could lead to severe dyspnea or even to respiratory failure. Coronary artery disease and/or cardiac arrhythmias are aggravated in the presence of hypoxia (low oxygen) or hypercarbia (increased carbon dioxide). Psychiatric disorders such as certain phobias or personality traits may preclude respirator use or may make a worker unreliable in using respirators. Other medical conditions can interfere

with safe respirator use such as perforated tympanic membranes (eardrums), structural abnormalities of the face (including full beards), and musculoskeletal disorders that make it difficult to carry the heavier respirators.

Purpose

The purpose of a Respiratory Protection Program at the NASA Lewis Research Center shall be to:

1. Identify those employees who, because of physical disability and/or disease, should not wear respirators because the added physiological burden of the respirator would be detrimental to that worker's health or his/her ability to safely perform their job.
2. Educate employees about the necessity of respiratory protection in certain work environments and how respiratory protection can prevent future medical problems when used properly.
3. Monitor employees who require respiratory protection to ensure that after an employee has been medically cleared to use a respirator, physical conditions do not emerge or digress to the point where continued respirator use would be contraindicated.

Medical Surveillance

In compliance with OSHA policy, all employees who use respirators regularly or who may use respirators on an emergency basis will have an annual limited physical examination with spirometry testing. Supervisors of NASA employees who need medical clearance for respirator use will provide a list of these employees to the Office of Environmental Program who, in turn, will share this list with the Occupational Medicine Services Office. The limited medical exams can be incorporated with the annual health screening physicals that are available to all NASA employees.

A Respiratory History for Spirometry Questionnaire will be completed by the employee. Any employee who has had a respiratory infection within three weeks before

the spirometry testing will be rescheduled. Additional medical history will be obtained during the physical that will concentrate on pulmonary, cardiovascular, neuromuscular, or physical problems which can adversely affect safe respirator use.

The physical exam for respirator clearance will concentrate on obtaining the employee's vital signs (blood pressure, pulse, respiratory rate, and temperature) and close examination of the employee's head, eyes, ears, nose, throat, mouth, neck, heart, lungs, and chest wall.

Spirometry testing will be obtained to calculate the employee's forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and FEV1/FVC (or FEV1%). While several other calculated values are extrapolated from spirometry testing, these three values best reflect an individual's functional lung capacity. When these three values are abnormal, the other values may then be of more value in the interpretation of the spirometry results, and additional tests may be indicated (e.g., chest X-ray, arterial blood gas sampling, diffusion capacity calculation, etc.). The spirometer that is used, the calibration of this instrument, and the interpretation of the results will comply with the "Standards for Administration and Interpretation of Ventilatory Function Tests," developed by OSHA in consultation with NIOSH (*Federal Register, Rules and Regulations*, Vol. 45, No. 42, Appendix B, pp 13695-13696).

An employee's spirometric test results will be compared to a set of reference standards and also compared to that employee's previous studies, if available. If the spirometry results are abnormal, repeat spirometry testing will be scheduled. If there is a significant decrement in an employee's pulmonary function when compared to previous studies, even if the employee's results fall within "normal limits," a repeat spirometry test will be scheduled. No more than two spirometry tests will be scheduled in a given calendar year if solely for the purpose of respirator clearance. "Normal" spirometry results are outlined in Table 1. Contraindications for respirator use are outlined in Table 2.

Table 1. Normal Spirometry Results

FVC	> 80% Age Predicted Value
FEV1	> 80% Age Predicted Value
FEV1% (FEV1/FVC)	> 70% (Actual Value)

Table 2. Contraindications for Respirator Usage

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1. Spirometry results fall below those values documented in Table 2.
 2. Uncontrolled cardiovascular disease (angina, valvular heart disease, known coronary artery disease, hypertension, or extracranial vascular disease).
 3. Uncontrolled epilepsy.
 4. Syncopal episodes.
 5. Myasthenia gravis, or other fatiguing neuromuscular disorders.
 6. Sleep apnea.
 7. Facial deformity (including the presence of beards) that render respirator fitting difficult, and adequacy of the seal cannot be guaranteed.
 8. Ill-fitting dentures.
 9. Severe kyphoscoliosis.
 10. Morbid obesity.
 11. Psychiatric disorders where reliability of respirator usage cannot be guaranteed.
 12. Perceived severe dyspnea (shortness of breath) when respirator is worn.
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All employees who meet the medical criteria for respirator usage will have a certificate sent to their supervisor with a copy sent to the Office of Environmental Programs. Similarly, employees who do not meet the criteria for respirator usage will have a certificate sent to their supervisor and the Office of Environmental Programs.

References

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2. Zenz, C. *Occupational Medicine: Principles and Practical Applications*, Second Edition, 1988: 250-253.
3. Altose, M.D. The Physiological Basis of Pulmonary Function Testing. *CIBA Clinical Symposia*, 1979.
4. Harber, P.H. Medical Evaluation for Respirator Use. *Journal of Occupational Medicine*, 1984; 26: 496-502.
5. 29 CFR, Section 1910.134.
6. *Federal Register, Rules and Regulations*, Vol. 45, No. 42, Appendix B: 13695-96.
7. *Occupational Lung Diseases, An Introduction*. American Lung Association, 1983: 1-80.

